

Stockpile Stewardship

Dense Plasma Focus (DPF)

Mission

In nuclear weapons applications, DPF plasma focus devices can be used as an external neutron diagnostic source during subcritical experiments -- called Neutron-Diagnosed Subcritical Experiments (NDSE). Other uses include flash neutron radiography and nuclear resonance spectroscopy, advanced neutron detection systems, system calibration, and nuclear forensics.

The important new application of NDSE, which dynamically measure reactivity, is currently being explored. The purpose of this class of experiment is to quantify the neutron multiplication ("chain reaction") that is the fundamental mechanism that generates energy in nuclear weapons. Neutron multiplication is extremely sensitive to compressibility of materials, and understanding compressibility under the conditions encountered in a nuclear weapon primary will be a key factor in the NNSA developing Life-Extension Program options (including pit reuse),

guarding against untoward aging effects, and establishing the safety/surety characteristics for the future stockpile. This class of experiment is similar to a Reaction History measurement on prior underground nuclear tests, except in NDSE the fissions are initiated by a short, intense pulse of neutrons injected around peak compression time, and the implosion is designed to remain below critical -- in adherence with U.S. policy to produce zero nuclear yield.

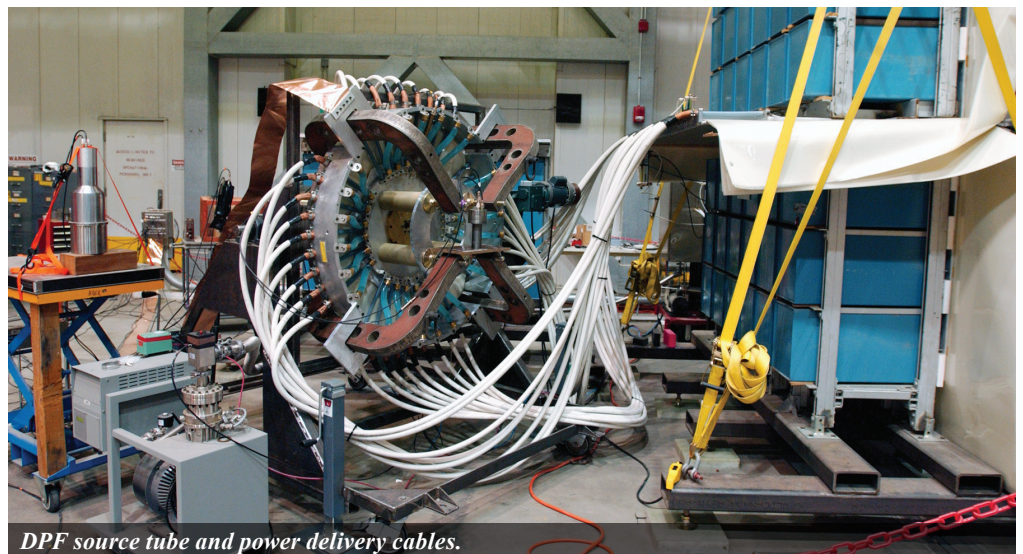
DPFs were invented about 50 years ago. During the last decade, NSTec has built a series of machines with steadily improving performance, repeatability, and reliability. These improvements have seen the DPF machines grow from a capacity of storing and quickly releasing less than 100 KiloJoules of energy to storing and releasing up to 2 MegaJoules. With over 6,000 DPF shots executed so far, operational flexibility has also greatly increased.

Re-assembling the DPF source.

Introduction

At the NNSS is a pulsed power machine that produces quick, highintensity bursts of nuclear fusionlike reactions. This is the latest dense plasma focus (DPF) machine designed and built by NNSS. The DPF is a machine that produces, by electromagnetic acceleration and compression, a short-lived plasma that is hot and dense enough to cause nuclear fusion and the emission of X-rays and neutrons under surface-of-the-Sun-type conditions.

The DPF is not hot or dense enough to produce fusion like in a star, but plasma instabilities do produce some very local heating and some very energetic beams that cause fast neutrons to be emitted.



DPF source tube and power delivery cables.



How It Works

Inside a dense plasma focus machine, light gasses are ionized and magnetically compressed to conditions similar to those inside the Sun. Like the Sun, the DPF machine allows gas atoms to fuse to form heavier products. This fusion releases large

amounts of energy primarily in the form of X-rays and neutrons.

In the NNSS DPF machines, up to 2 MegaJoules of energy is stored in large capacitors at voltages of up to 70,000 volts. When released, the stored energy drives large currents, creating intense magnetic fields; the high voltage causes high electrical fields in the gas-containing source tube. The high voltage causes the gas to become ionized, which transforms the gas into current-carrying plasma. The intense magnetic fields compress the plasma into a very small volume, making it dense and hot; hence the name "Dense Plasma Focus".

Unlike conventional radionuclide neutron sources that emit neutrons over a broad range of energies, DPF fusion devices are mono energetic. This characteristic is beneficial for many types of physics experiments; for instance, measuring nuclear cross-sections. Also, the DPF

emits neutrons in very short bursts, unlike radioactive and reactor sources that can produce neutrons continuously. DPF machines are quite compact in comparison to large accelerators that are used as neutron sources; this makes them ideal for applications where space is a premium or where transportability is required. These defining characteristics provide a research and application niche in which the DPF excels as a tool to accomplish high quality research quickly and efficiently.

Improvements to performance, repeatability, capacity, and reliability that NNSS has achieved are due to iteration and characterization of plasma tube design, source/drive tailoring and characterization; sophisticated timing, firing and control systems, and concurrent modeling of all processes from current flow to plasma production.

The NNSS DPF laboratories have been used by the national security enterprise, research and development programs, and universities. They have been used for a wide variety of physics experiments, including stockpile stewardship instrumentation development, Teller light experiments (very early radiation from nuclear explosions), and the measurement of physical quantities such as material properties, nuclear crosssections, and for quantifying the performance of specialized systems ranging from homeland security to national defense.



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